Technical Evaluation Report

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1.0 TECHNICAL EVALUATION

HFM-181 Symposium on Human Performance Enhancement for NATO Military Operations (Science, Technology and Ethics) was held in Sofia, Bulgaria from 5 through 7 October. The meeting was chaired by COL Karl Friedl (USA) and Dr. Pang Shek (CAN). The symposium's theme was the facilitation of a broader understanding of the promise and pitfalls of Human Performance Enhancement (HPE) technologies in NATO military settings. Specific aims were to identify areas in which coordinated research efforts are required to expand understanding of the existence, effectiveness, potential health risks and options for applications of human performance enhancement technologies to current and future NATO operations. Participants represented a broad range of allied, partner and affiliated countries presenting 30 papers, 2 keynotes and 15 posters on a range of topics pertinent to the theme and specific aims of the symposium.

The symposium began with a presentation from the symposium Chairs defining the issues and scope of discussion. This was helpful in framing the issues and priming discussions that followed and is a practice that other symposium chairs should consider. This technical evaluation follows from the introductory remarks of the symposium Chairs to identify stated and implied symposium findings and recommendations. Where the report identifies an insufficiency, a concomitant recommendation is offered as a way forward.

1.1 Keynote Speakers

The meeting included two noteworthy keynote presentations. Both keynote speakers spoke about the folly of presuming that technological superiority alone can win both the war and the ensuing peace. The first keynote was presented by Prof. Dr. Ira Jacobs (CAN) on exploiting human science advances for military operations. He defined human sciences as an interdisciplinary field that involves the application of biological, behavioral & socio-cultural knowledge for the purposes of understanding those capabilities and limitations of relevance to the missions of our nations' military and national security organizations. He cautioned researchers in the field that whereas nonmilitary research focuses on identifying and treating abnormal function in a normal

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
OCT 2009	**N/A**	**-**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Technical Evaluation Report	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **US Army Medical Research and Materiel Command Telemedicine and Advanced Technology Research Center Medical Research and Advanced Technology Liaison Gruppe Wehrpsychologie Streitkäfteamt Bonn, Germany**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution unlimited

13. SUPPLEMENTARY NOTES
See also ADA562561. RTO-MP-HFM-181 Human Performance Enhancement for NATO Military Operations (Science, Technology and Ethics) (Amelioration des performances humaines dans les operations militaires de l'OTAN (Science, Technologie et Ethique)). RTO Human Factors and Medicine Panel (HFM) Symposium held in Sofia, Bulgaria, on 5-7 October 2009., The original document contains color images.

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**SAR**	**10**	

environment, the objective of military human sciences research should be to sustain at least normal function in the very abnormal environments which characterize most military operations.

The second keynote was presented by Prof. Dr-Eng Axel Schulte (GER) on enhancing human-machine system performance by introducing artificial cognition in vehicle guidance and targeting systems. Dr. Schulte presented research on introducing automated systems for the control of multiple remote-controlled aerial vehicles that reduce operator workload and minimize system complexity, which is a primary contributor to human error. He emphasized that expert systems (cognitive units) can be designed for skill and rule-based behaviors. However, knowledge-based intentional systems that define work objectives are too complex to emulate in automated cognitive units and ultimately result in rule-based modal action patterns rather than true knowledge-based intentional behavior. Dr. Schulte's experimental results show promise in dividing labor between human and machine such that multiple UAV's can be controlled by a single operator to successfully engage targets and creatively respond to the inevitable uncertainties in tactical aerial engagements.

1.2 Presentations and Posters

The scientific meeting framed two categories of human performance research conducted for one of three purposes in operational environments. The two categories are research involving human/machine integration and research which focuses on the biology and behavior of the human. The three purposes defined were Human Performance Enhancement (HPE), Human Performance Optimization (HPO), and Human Performance Maintenance (HPM). HPE was defined as the induction of supra-normal phenotypes. HPO was defined as facilitating the expression of desired naturally expressed phenotypes. HPM was defined as maintaining or sustaining the expression of desired naturally expressed phenotypes.

All experimental research presented was on technologies designed to maintain or facilitate natural abilities of the typical NATO service member to protect the health and safety of the service member, while maintaining or facilitating desired performance as defined by operational challenges. The broad scope of topics covered in a limiting schedule afforded insights into the art of the possible in enhancement technologies, but left little room for coordinated debate and deliberation over critical issues. For example, although alluded to, the ethical debate was never fully engaged concerning HPE. The only clear policy statement concerning ethical practice was made by the Canadians, who said their policy is that they only engage in HPM/HPO research and not HPE research. However, HPM and HPO manipulations are not immune to bioethical dilemmas.

With the burgeoning use of nutraceuticals,[1] control of soldiers' diet is virtually impossible and adverse interactions between nutraceutical use and prescribed HPO/HPM measures was a concern raised among the symposium attendees. Also expressed by symposium members was a serious concern over the general public's increasing "off-label" use of prescription drugs.[2] The symposium members were unclear as to the extent of the problem in the military and are concerned about the informal distribution and unmonitored use of these medications to sustain performance. Recognizing that acquiring reliable prevalence data will be difficult, the development of health risk communication programs are recommended (1) to reinforce service member compliance in maintaining health and fitness habits and (2) to ensure the efficacy of prescribed mission essential application of HPO/HPE pharmacologies.

[1] Nutraceutical: *A class of dietary supplements (food or extract) acquired without need of prescription used in the prevention or treatment of disease or disorder or for the purpose of augmenting desired traits*. (e.g., Fitts, Alexis (September 5, 2009). Round up: Smart Drugs. Wired Magazine, Product Reviews, http://www.wired.com/reviews/product/pr_studydrugs)

[2] Lamb, Gregory (May 10, 2009). Pill wars: debate heats up over 'brain booster' drugs. Christian Science Monitor, http://www.csmonitor.com/2009/0515/p13s01-ussc.html

Most of the scientific presentations were without hypotheses that would suggest experiments to elucidate mechanisms which might threaten health in an attempt to provide enhanced or sustained performance. This issue appears to stem from three fronts. The policy concerning experimentation in HPE/HPO is unclear. The lack of leadership in this area provides insufficient guidance for identifying under which conditions and to what extent performance enhancement technologies are to take precedence over the potential associated health risks. The problem also appears to stem from the NATO community's limited research into pragmatic solutions to problems facing service members in the field and from a lack of theoretical underpinning to frame hypotheses to elucidate mechanisms regulating health and performance.

In terms of the policy leadership issue, the HFM Panel Chair, Dr. Bernd DeGraaf (NLD) is acting on the symposium recommendation and will be convening an exploratory team to discuss performance-related bioethical issues. The team will be charged with presenting recommended HPE/HPO policy to the NATO members. This team should also issue recommended guidance to NATO member researchers concerning performance expectations of service members in current and future NATO operations. The framing of context is important to modeling, developing research programs and generalizing experimental results to current NATO operations and to inform future operational planning.

In terms of pragmatic solutions to relevant problems, research can be driven by operational problems or by theory. With few exceptions, the research presented at the symposium was driven by theory. The notable exception was work on the development of micro-climate cooling systems presented by Dr. Cheuvront (USA). The problem was how to reduce power requirements of the cooling system while maintaining thermoregulatory efficiency. Dr. Cheuvront used current scientific knowledge of thermoregulation to target cooling to critical areas based on skin temperature feedback. Targeted cooling improved work sustainment and significantly reduced system power and weight requirements. This advance has accelerated equipping service members with a device that will sustain performance in environments that currently prohibit sustained exertion due to risk of heat-related injury.

In terms of theoretical underpinning, problem oriented research can solve immediate real-world issues but one must recognize presuppositions of one's approach and understand the implications for reasoning about a problem. Without such a recognition, alternate approaches to the problem are not easily recognized and mechanisms not well understood, leaving potential solutions undiscoverable. To reinvigorate an apparent impoverished hypothesis generation process, some alternate perspectives are offered as examples to facilitate abduction[3] and the exploitation of serendipitous findings.

Physiologic status monitoring, utilizing biomarkers of fatigue, stress, anxiety and nutritional state offers the potential for real-time assessment of threats to service member heath and performance. Once data are collected there remains the problem of fusing and interpreting the data set. Here the researcher typically assigns meaning to the results through mapping the collection of observations to a model or theory. The utility of the theory or model is determined by how well it informs us of likely future outcomes. Since theories cannot be both consistent (predictive) and complete (explain all possible instances) the choice of the theory will set the presuppositions for interpreting results.[4] For example, in monitoring indices of the cardiovascular system in response to cold exposure to the face of an unacclimated individual, the response

[3] Peirce, C. (1958). The Collected Papers of Charles Sanders Peirce. In A.W. Burks (Ed.), Harvard University Press, Cambridge University.
Abduction: *a process of finding premisses; the basis of interpretive reconstruction of causes and intentions, as well as of inventive construction of theories*.
[4] Hofstadter, D. (1999). Gödel, Escher, Bach: An eternal golden braid. Basic Books, New York. ISBN 0465026567

includes tachycardia and increased blood pressure.[5] This condition puts some at risk for acute myocardial infarction with increases in this event associated with seasonal changes in temperature.[6] With repeated exposure, the system adapts and responses to cold exposure include bradycardia, little change in blood pressure and increased skin temperature.[8] The issue for systems like physiologic status monitors is under what circumstances do physiologic changes suggest a threat of exhaustion[7] or a pending adaptation[8]. The issue is important to HPE/HPO because a misinterpretation of physiologic regulatory status could lead to the misapplication of HPE/HPO technologies.

Social and emotional regulation are also important to heath and performance and thus a shift in the level of analysis from the individual to the team is required. The shift does not exclude physiologic metrics, since social and emotional exchange have definite regulatory effects on individuals.[9,10,11] This shift in focus would add a much needed social level to the current dominant individual level of analysis of health and performance. This shift would further acknowledge the "psychological fog" of war[12] and the impact of morale and cohesion on health and performance, opening new possibilities for enhancement and optimization technologies.

1.3 Recommendations 1 & 3: HPE Ethical Boundaries and Due Diligence

NATO nations should decide, at a minimum, on bioethical boundary conditions before medical and materiel performance enhancement technology significantly outpaces policy. The ethical and social consequences of implementing invasive procedures (e.g., transcranial magnetic stimulation) should be evaluated not only with regard to mission requirements but also with regard to undesired consequences that may emerge during the expected life span of the Soldier (70 years). The Canadian statement notwithstanding, a clear consensus statement by the panel of the rejection or acceptance of ethical boundary conditions for HPE research was not made. In fairness, this was an aggressive symposium schedule and only one panel session was devoted to ethics. The time allocated only allowed for a framing of the debate.

The context was set by the keynote speakers who spoke to the folly of presuming technological superiority alone can win both the war and the ensuing peace. LTC Dr. Trousselard (FRA) presented the first paper in which the argument was put forth that since the members of the services volunteer to be in harm's way and because these service members are healthy and in life-threatening situations, HPE technology may appropriately be applied for the purposes of the mission. Considering this position, the question was raised and left for the panel: Given this special case, under what circumstances would the application of HPE be ethical and under what circumstance would it be unethical? CDR Dr. Meijer (NLD) said that given this special case, soldiers' free will, for example, to take a drug, is taken away and thus accountability for the soldier's actions may not rest with the soldier but with those who gave the order or who administered the

[5] Eckberg, D., Mohanty, S. & Raczowska, M. (1983). Trigeminal-baroreceptor reflex interactions modulate human cardiac vagal efferent activity. Journal of Physiology, 347, 75-83.
[6] De Lorenzo, F., Sharma, V., Scully, M. & Kakkar, V. (1999). Cold adaptation and the seasonal distribution of acute myocardial infarction. Quarterly Journal of Medicine, 92, 747-751.
[7] Selye, H. (1936). A syndrome produced by diverse nocuous agents. Nature, 138, 32. doi: 10.1038/138032a0
[8] McEwen, B. (2000). Allostasis and allostatic load: Implications for neuropsychopharmacology. Neuropsychopharmacology, 22(2), 108-124. doi:10.1016/S0893-133X(99)00129-3
[9] Hofer, M. (1981). The Roots of Human Behavior. Freeman, Cooper & Company, New York, NY.
[10] Thayer, J. & Lane, R. (2009). Claude Bernard and the heart–brain connection: Further elaboration of a model of neurovisceral integration. Neuroscience and Biobehavior Reviews, 33(2), 81-88. doi:10.1016/j.neubiorev.2008.08.004.
[11] Friedman, B. (2007). An autonomic flexibility-neurovisceral integration model of anxiety and cardiac vagal tone. Biological Psychology, 74, 185-199. doi:10.1016/j.biopsycho.2005.08.009
[12] Clausewitz, C. (2007). On War. Oxford University Press, Inc. New York, NY.

drug. COL Dr. Brown (USA) argued for the need for a common doctrine that balanced the strategic need for superior weapon systems with that of ethical considerations and cautioned against an arms race mentality in crafting doctrine. COL Dr. Walker (CAN) noted that performance enhancement is not considered ethical practice in Canada. Further, in terms of the free will issue, Canadian service members can refuse performance sustainers but the choice does not remove the responsibility of the service member from sustaining performance. Further, the Canadian's practice a "due diligence" policy. They are required to consider 4 questions before dispensing a performance maintaining agent:

- Is the use truly informed and voluntary?
- Is the agent safe for individual and operational environment?
- Is the use consistent with dose and pharmacology?
- Has due diligence been applied in that all other alternatives have been exhausted?

The final panel member presentation was by COL Dr. Bigard (FRA). He noted that for "due diligence" to be most effective, it is the responsibility of the military medical performance research communities to find solutions that mitigate circumstances that lead to situations of moral/ethical dilemma. COL Dr. Bigard presented a heuristic suggesting boundary conditions for selection, training, equipment, pharmacology, surgery and genetics. These boundary conditions were referenced to acceptable selection, equipping, training, and nutritional practices for elite athletes. COL Dr. Bigard's heuristic is recommended as a starting point for further bioethical debate of HPE.

During discussions, a recurring theme was that scientists were continually faced with finding means to sustain human performance to ameliorate the effects of critical personnel shortages (e.g., use of SSRI's to retain pilots on flight status, COL Mckeon (USA)). Pushing the limits of sustaining human performance was acknowledged as pushing the limits of health and safety. However, how far one can push those limits and under what conditions was considered a matter of doctrine and policy debate, which requires engagement of a broad representation of the military community. As mentioned earlier, Dr. DeGraaf (NLD) is convening an exploratory panel to engage these open questions as recommended by the Panel.

In sum, the presentations of the panel and points raised by the symposium attendees suggested the following boundary conditions:

The human should not to be considered a weapon system developed through

- replacing normal functioning tissue and organs with prostheses,
- implanting machine systems in normal functioning tissues and organs, or
- creating biologically hopeful monsters[13] by means of genetic, proteomic, physiologic or teratogenic agent manipulation.

1.4 Recommendation 2: Health and Fitness versus Performance Standards

The distinction between health and fitness and that of performance was a recurring theme, with a number of participants recommending the dissociation of health standards from those of performance standards. This was argued for two reasons: 1) metrics of health are poor predictors of performance; 2) there is an associated attrition of health and fitness with deployment. Ms. Marilyn Sharp (USA) reported that post-deployment health and fitness measures showed decreased aerobic fitness, increased body fat, and increased incidents of injury compared with predeployment data. This relationship requires further study to determine the rate at

[13] Castle, D. (2003). Hopes against hopeful monsters. The American Journal of Bioethics, 3(3), 28-30.

which health and fitness degrades and to determine the specific associations with the tasks service members perform. This information would be useful for optimizing work rest cycles and for rotating team assignments to missions (e.g., guard, patrol, convoy, etc.).

The distinction was also related to Initial Entry Training where gender differences in health and fitness put women at unnecessary risk for stress fractures. A main purpose of Initial Entry Training is to train service members to a baseline health and fitness level in preparation for advanced training in their particular military occupation. Two concerns were raised. One concern raised by Mr Scott (GBR) was that unfit men and women respond to and recover from load bearing exercise in different manners. These differences in physiology put unfit women in a higher risk category for stress fractures than men. The argument was not for changing the rigor of health and fitness training and standards, but for modifying the tempo of heavy work versus recovery in training service members to baseline fitness levels. The second concern was that recruits are presenting with higher body fat to lean muscle mass ratios and that the implications for Initial Entry Training and nutrition are yet unknown. The Germans have presented epidemiological data on this issue in other forums and in the open literature. The other NATO allies, partners and affiliates report similar trends in the decreasing general activity, increasing body fat to lean muscle ratios and increasing incidence of Type II diabetes in the recruitment pool.

Given such concerns, the use of physiological status monitoring is encouraged in the training environment to assist the Initial Entry Training cadre and medical monitors in tailoring programs to individuals and in assessing health and fitness outcomes. The reports, in particular by the Netherlands, show that important advances in physiologic status monitoring makes the system an invaluable monitor of individual health as recruits train up to fitness baselines.

1.5 Recommendation 4: Develop cooperative data exchange and project agreements

The NATO military medical operational performance research communities need to establish cooperative research programs under program and data exchange agreements along the model set by those in the engineering and materiel development research communities. Further, NATO countries are encouraged to engage in the exchange of scientists and engineers in a coordinated manner and at the level set by those in the engineering and materiel development research communities.

There were a total of 45 scientific presentations and only one presented work performed under a multinational data exchange agreement. That paper was from the materiel development community and the agreement was established by that community (Dr. Dudfield (GBR)). The medical community was queried about cooperative agreements and one individual believed there existed a US Navy agreement but was unsure with whom or if it was active. No medical researcher at the symposium was participating in an international protocol.

As commented earlier, there are personnel shortages in conflict areas where NATO troops are currently deployed. This strain results in a high operations tempo for deployable service members and requires solutions to sustaining performance to meet the high operations tempo. Under these circumstances, commanders are owed options for due diligence. Working cooperatively leverages expertise and technology and establishes common best practices and interoperability in sustaining international forces. Such efforts would, at a minimum, identify divergent points of view in HPO/HPE, thus facilitating discussion and consensus. Optimally, working cooperatively could result in policies and practices that mitigate circumstances which lead to situations of moral and ethical dilemma in the research and application of HPO/HPE technologies.

1.6 Recommendations 5 & 6: One must enhance performance within a context

There was only one team-oriented paper presented. That paper was on communication trust in robustly networked operations, presented by the materiel developers (Dr. Dudfield (GBR)). A team perspective is important because it approaches HPO from a selection perspective in putting those individuals with desired traits in the right jobs (e.g, Dr. Carney (USA)). The majority of the papers were on individual physiology or physiologic mechanisms with application to NATO operations limited. This is in part because most research in the field of physiology depends on specialized equipment and measurement techniques that restrict the ability to study physiologic mechanisms in applied or natural settings. Advances in the development of physiologic status monitoring, in particular reported by the Netherlands, has the potential to ameliorate this issue. Notwithstanding, the lack of application seemed to also stem from a lack of specific experience and knowledge of operational and tactical realities. Better communication between the research community and the military operational community is needed. This would improve the direction and emphasis of military medical operational performance research. Perhaps some sort of program director qualification experience is needed. This program could entail two phases. In one phase, research program directors would spend time observing and working with units in the field to gain a first hand understanding of current operational health and performance concerns. In a second phase, research program directors would spend some time observing those involved with strategic planning to gain insight into health concerns and performance expectations in potential future conflict.

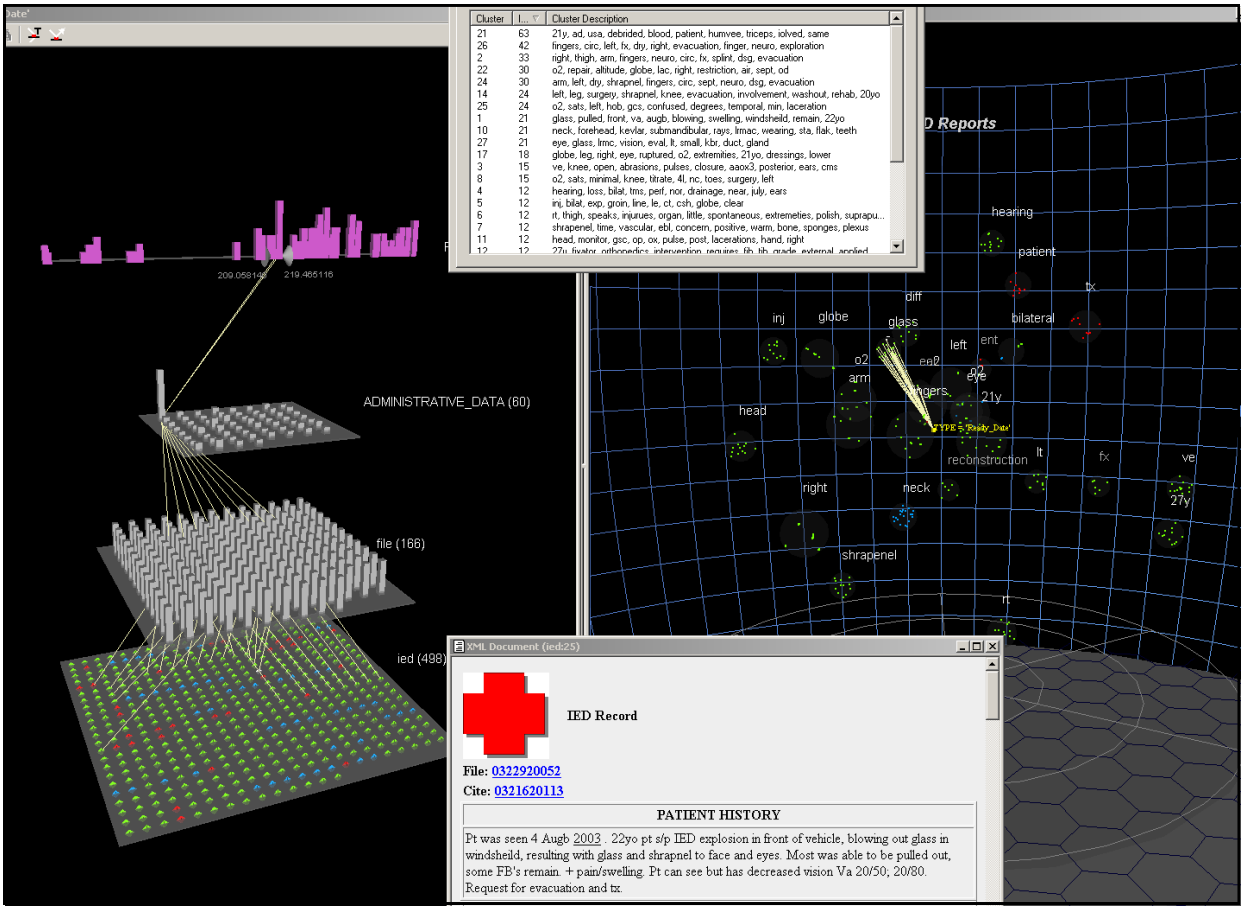

Figure 1. Data patterned with a force directed model. The graphic shows resulting link arrays linked to time (left panel) and concept clusters (right panel and top insert box).

Another means to help shape relevant research is to improve knowledge management, a point raised by LTC Kostadinov (BGR). A means to better visualize and understand tactical and operational medical issues to ask more informed questions is to employ data visualization techniques on existing data sources. These techniques allow for the systematic aggregation of data from disparate sources to render visually based information in both the spatial and temporal domains. Figures 1 and 2 present visual representations of data from existing disparate sources. Figure 1 shows data from existing evacuation data sources associated in link arrays (left) and concept clusters (right). Figure 2 shows a human terrain map rendered from existing Gallup survey data concerning the attitudes of Iraqis in Bagdad to initial coalition operations. The referenced data were published in an unclassified report on protecting service members from improvised explosive devices.[14] Materiel, medical and training solutions were implemented based on the information from the report. Such information would give the researcher the required situational awareness to develop relevant programs and timely solutions. NATO should consider an accessible knowledge management program to improve the mechanisms for learning from past and current experiences and to guide military medical operational performance research.

[14] Ness J. (2004). Techniques for "Data Mining" IED incident reports. In J. Manus et al. (Eds.), An Analysis of Improvised Explosive Device Employment. Final Report to Rapid Equipping Force, FT Belvior, VA.

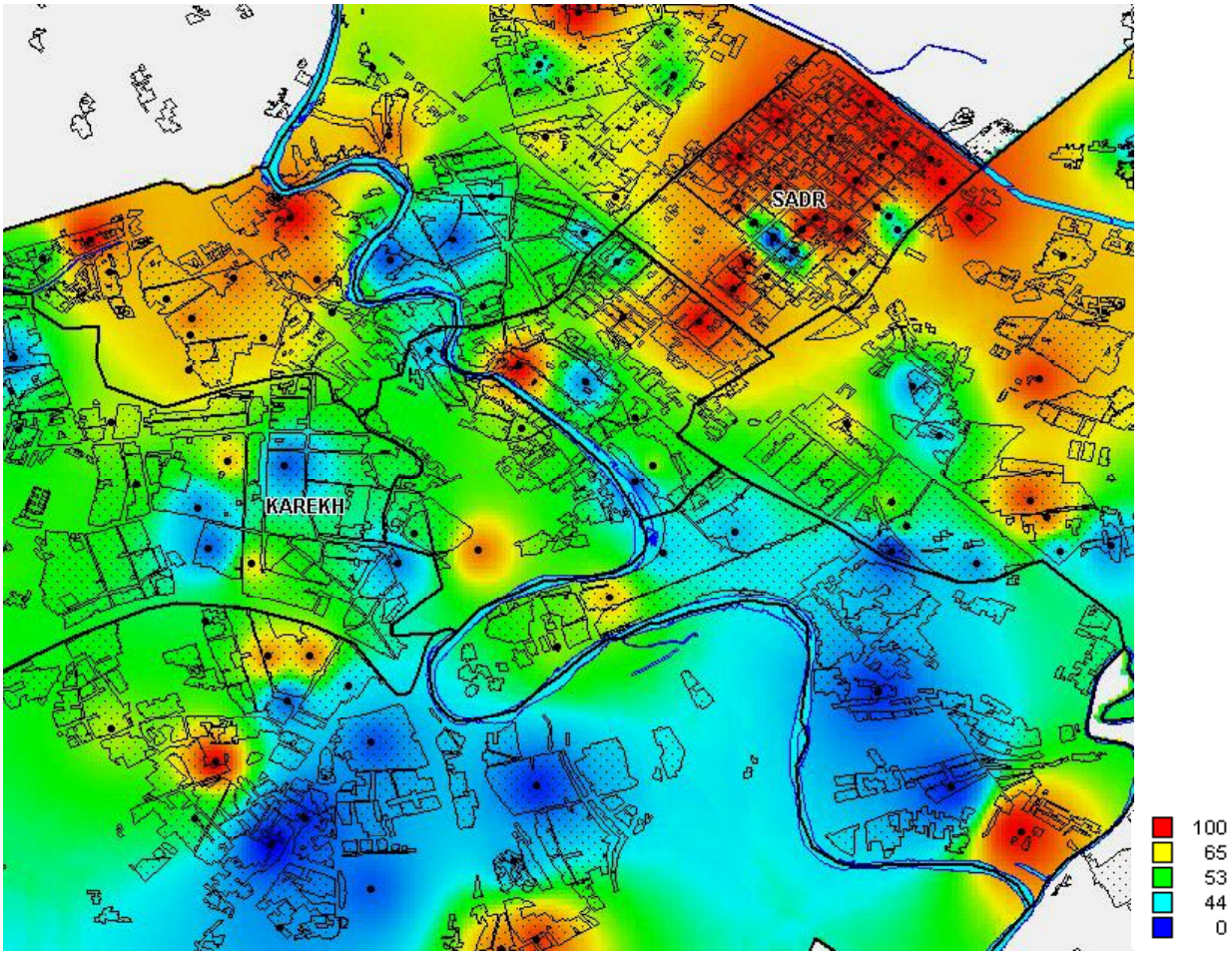

Figure 2. Data patterned with false color rendering of percentages of responses within neighborhoods to the question: "Thinking about any hardships you might have suffered since the U.S.-Britain invasion, do you personally think that ousting Saddam Hussein was worth it?"

1.7 Conclusions and Recommendations

In conclusion, the following specific recommendations are offered:

- NATO nations should decide, at a minimum, on bioethical boundaries before medical and materiel performance enhancement technology significantly outpaces policy.
- Health and fitness standards should be separate from performance standards, since health and fitness are foundational to but not predictive of performance.
- A goal of military operational performance research should be to provide commanders with options for "due diligence" in deciding to authorize the use of performance-sustaining or enhancing modalities which risks long-term health and fitness of service members.

- The NATO military medical operational performance research communities need to establish cooperative research programs (e.g., data exchange agreements, joint research) following the model set by those in the engineering and materiel development research communities.
- National and NATO leader development programs for research program directors should be implemented to educate them on current and future operational and strategic threats, environments and associated service member and unit performance expectations.
- NATO should establish a knowledge management program to mine patterns in force health and performance in current and past conflicts and exercises to drive research programs.

ACKNOWLEDGEMENTS

The authors thank Dr. David Lam for his critical review and noteworthy contributions to this evaluation.

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